

DESCRIPTION

SUBTYPES OF HUMANIZED ANTIBODY AGAINST
INTERLEUKIN-6 RECEPTOR

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Technical Field

The present invention relates to novel subtypes of the humanized PM-1 antibody which is an antibody against interleukin-6 receptor (IL-6R).

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Background Art

Though proteins produced by gene recombinant technology should have an amino acid sequence predicted from the gene sequence, a number of variants may actually be produced. This is due to known or novel in vivo (post-transcription) modification or naturally occurring (non-enzymatic) proteolysis (R.J. Harris, J. Chromatogr. A 705 (1995) 129-134). Since proteins for use as ingredients of pharmaceutical drugs are produced by gene recombinant technology utilizing in vivo biosynthetic processes, there is a possibility that subtypes having different molecular structures may be produced. The kinds and contents of subtypes define the quality of pharmaceutical drugs, and therefore it is important to characterize the subtype profiles and assure their usefulness as pharmaceutical compositions.

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IL-6 is a cytokine which is also called B cell stimulating factor 2 (BSF2) or interferon β 2. IL-6 was discovered as a differentiation factor involved in the activation of B-lymphatic cells (Hirano, T. et al., Nature (1986) 324, 73-76). Thereafter, it was found to be a multifunctional cytokine that influences various functions of the cell (Akira, S. et al., Adv. in Immunology (1993) 54, 1-78). IL-6 has been reported to induce the maturation of T-lymphatic cells (Lotz, M. et al., J. Exp. Med. (1988) 167, 1253-1258).

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IL-6 transmits its biological activity through two types of proteins on the cell. One type is interleukin-6

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receptor (IL-6R), a ligand-binding protein with a molecular weight of about 80 kD, to which IL-6 binds (Taga, T. et al., *J. Exp. Med.* (1987) 166, 967-981; Yamasaki, K. et al., *Science* (1987) 241, 825-828). IL-6R occurs not only in the membrane-bound form that penetrates through and is expressed on the cell membrane but also as a soluble IL-6R consisting mainly of the extracellular region.

Anti-IL-6R antibody has been described in several reports (Novick D. et al., *Hybridoma* (1991) 10, 137-146, Huang; Y. W. et al., *Hybridoma* (1993) 12, 621-630; International Patent Publication WO 95-09873; French Patent Application FR 2694767; United States Patent US 521628). A known Humanized PM-1 antibody was obtained by transplanting the complementarity determining region (CDR) of a mouse antibody PM-1 (Hirata, Y. et al., *J. Immunol.* (1989) 143, 2900-2906), to a human antibody (International Patent Publication WO 92-19759).

However, subtypes of the humanized PM-1 antibody are not known.

Patent document 1: WO 92/19759

Patent document 2: Japanese Unexamined Patent Publication (Kokai) No. 8-99902

Patent document 3: French Patent Publication FR 2694767

Patent document 4: U.S. Pat. No. US 521628

Non-patent document 1: R.J. Harris, *J. Chromatogr. A* 705 (1995) 129-134

Non-patent document 2: Hirano, T. et al., *Nature* (1986) 324, 73-76

Non-patent document 3: Akira, S. et al., *Adv. in Immunology* (1993) 54, 1-78

Non-patent document 4: Lotz, M. et al., *J. Exp. Med.* (1988) 167, 1253-1258

Non-patent document 5: Taga, J. *Exp. Med.* (1987) 166, 967-981

Non-patent document 6: Yamasaki, K. et al., *Science*

(1987) 241, 825-828

Non-patent document 7: Novick, D. et al., Hybridoma (1991) 10, 137-146

5 Non-patent document 8: Huang, Y.W. et al., Hybridoma (1993) 12, 621-630

Non-patent document 9: Hirata, Y. et al., J. Immunol. (1989) 143, 2900-2906

Disclosure of the Invention

10 Thus, the present invention relates to novel subtypes of the humanized PM-1 antibody and a pharmaceutical composition comprising said subtypes.

15 After careful separation of the recombinantly produced humanized PM-1 antibody, the present inventors have found that there is a molecular species in which Gly at the C-terminal (position 448) of the constant region constituting the heavy chain of the humanized PM-1 antibody is lost and Pro at position 447 has been amidated, as well as an antibody subtype (referred to as subtype 1) in which only one of the two heavy chains 20 constituting the antibody has been amidated and an antibody subtype (referred to as subtype 2) in which both have been amidated. Furthermore, the present inventors have found that both of the above subtypes retain the same antigen-binding activity and cell growth-inhibiting 25 activity as the native antibody in which the C-terminal is Gly (448), and have thus completed the present invention.

30 Thus, the present invention provides an antibody subtype (1) which is a subtype of the humanized PM-1 antibody against interleukin-6 receptor (IL-6R) and in which one C-terminal of the heavy chain is Pro-NH₂ (447), and an antibody subtype (2) which is a subtype of the humanized PM-1 antibody against interleukin-6 receptor (IL-6R) and in which both C-terminals of the heavy chain are Pro-NH₂ (447). The native heavy chain C-terminal of 35 the humanized PM-1 antibody corresponding to both of the above subtypes is Gly (448). In a preferred embodiment,

the native heavy chain corresponding to the amidated heavy chain subtype has the amino acid sequence set forth in SEQ ID NO: 1. In a preferred embodiment, glutamine (Gln) at the heavy chain N-terminal has been replaced 5 with pyroglutamic acid (pGlu). Also, in a preferred embodiment, the light chain constituting the antibody subtype of the present invention has the amino acid sequence set forth in SEQ ID NO: 2.

10 The present invention also provides a pharmaceutical composition comprising either subtype (1) or subtype (2) described above, or both subtypes (1) and (2).

Brief Explanation of the Drawings

15 Fig. 1 shows the result of liquid chromatography in the liquid chromatography (LC)-mass spectrometry (MS) of the peptide fragment SLSLSP, in which the top graph is a chromatogram detected by a UV at 215 nm and the bottom graph is a base peak chromatogram.

20 Fig. 2 shows a mass spectrum in the liquid chromatography (LC)-mass spectrometry (MS) of the peptide fragment SLSLSP.

Fig. 3 shows a zoom scan spectrum in the liquid chromatography (LC)-mass spectrometry (MS) of the peptide fragment SLSLSP.

25 Fig. 4 shows the result of liquid chromatography in the liquid chromatography (LC)-mass spectrometry (MS) of the peptide fragment SLSLSP-NH₂, in which the top graph is a chromatogram detected by a UV at 215 nm and the bottom graph is a base peak chromatogram.

30 Fig. 5 shows a mass spectrum in the liquid chromatography (LC)-mass spectrometry (MS) of the peptide fragment SLSLSP-NH₂.

Fig. 6 shows a zoom scan spectrum in the liquid chromatography (LC)-mass spectrometry (MS) of the peptide fragment SLSLSP-NH₂.

35 Fig. 7 shows the result of liquid chromatography in the liquid chromatography (LC)-mass spectrometry (MS) of the mixture of the peptide fragments SLSLSP and SLSLSP-

NH₂, in which the top graph is a chromatogram detected by a UV at 215 nm and the bottom graph is a base peak chromatogram.

5 Fig. 8 shows a mass spectrum of the peak at a retention time of 44 minutes in Fig. 7.

Fig. 9 shows a mass spectrum of the peak at a retention time of 51 minutes in Fig. 7.

10 Fig. 10 A shows a peptide map of peptides obtained by the reduction/carboxymethylation of the humanized PM-1 antibody (Main) followed by trypsin digestion; Fig. 10 B shows the MS chromatogram of molecular weight of SLSLSPG (selective monitoring at m/z 660.3 ± 0.5), Fig. 10 C shows that of SLSLSP-NH₂ (selective monitoring at m/z 602.3 ± 0.5), and Fig. 10 D shows that of SLSLSP 15 (selective monitoring at m/z 603.3 ± 0.5).

20 Fig. 11 shows the result of LC-MS/MS analysis of a peptide obtained by the reduction/carboxymethylation of the humanized PM-1 antibody (Main) followed by trypsin digestion, in which the top is a chromatogram detected by a UV at 215 nm and the bottom is a base peak chromatogram.

Fig. 12 shows a mass spectrum of the peak at a retention time of 50 minutes in Fig. 11.

25 Fig. 13 shows a zoom scan spectrum of the same peak as in Fig. 11.

Fig. 14 A shows a peptide map of peptides obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 1 followed by trypsin digestion; Fig. 14 B shows the MS chromatogram of molecular weight of 30 SLSLSPG (selective monitoring at m/z 660.3 ± 0.5), Fig. 14 C shows that of SLSLSP-NH₂ (selective monitoring at m/z 602.3 ± 0.5), and Fig. 14 D shows that of SLSLSP (selective monitoring at m/z 603.3 ± 0.5).

35 Fig. 15 shows the result (on the peak in Fig. 17 B) of liquid chromatography in the LC-MS/MS analysis of a peptide obtained by the reduction/carboxymethylation of

the humanized PM-1 antibody subtype 1 followed by trypsin digestion, in which the top is a chromatogram detected by a UV at 215 nm and the bottom is a base peak chromatogram.

5 Fig. 16 shows a mass spectrum of the peak at a retention time of 48 minutes in Fig. 15.

Fig. 17 shows a zoom scan spectrum of the same peak as in Fig. 16.

10 Fig. 18 shows the result (on the peak in Fig. 17 C) of liquid chromatography in the LC-MS/MS analysis of a peptide obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 1 followed by trypsin digestion, in which the top is a chromatogram detected by a UV at 215 nm and the bottom is a base peak chromatogram.

15 Fig. 19 shows a mass spectrum of the peak at a retention time of 46 minutes in Fig. 18.

Fig. 20 shows a zoom scan spectrum of the same peak as in Fig. 19.

20 Fig. 21 A shows a peptide map of peptides obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 2 followed by trypsin digestion; Fig. 21 B shows the MS chromatogram of molecular weight of SLSLSPG (selective monitoring at m/z 660.3 ± 0.5), Fig. 21 C shows that of SLSLSP-NH₂ (selective monitoring at m/z 602.3 ± 0.5), and Fig. 21 D shows that of SLSLSP (selective monitoring at m/z 603.3 ± 0.5).

25 Fig. 22 shows the result of liquid chromatography in the LC-MS/MS analysis of a peptide obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 2 followed by trypsin digestion, in which the top is a chromatogram detected by a UV at 215 nm and the bottom is a base peak chromatogram.

30 Fig. 23 shows a mass spectrum of the peak at a retention time of 45 minutes in Fig. 22.

Fig. 24 shows a zoom scan spectrum of the same peak

as in Fig. 23.

Best Mode for Carrying out the Invention

The native humanized PM-1 antibody corresponding to the antibody subtype of the present invention is an antibody in which the complementarity determining region (CDR) in the variable region (V region) constituting the heavy chain (H chain) and the light chain (L chain) of a mouse monoclonal antibody termed PM-1 against IL-6R has been replaced with the corresponding CDR region of the human antibody V region. The amino acid sequence of the CDR of the L chain V region of the above mouse anti-IL-6R antibody is described in CDR 1, CDR 2 and CDR 3 on the line of L_v PM-1 in Table 2 of International Patent Application WO 92/19759, and the amino acid sequence of the CDR of the H chain V region of the above mouse anti-IL-6R antibody is described in CDR 1, CDR 2 and CDR 3 on the line of H_v PM-1 in Table 3 of International Patent Application WO 92/19759.

The framework region (FR) of the L chain V region of the above humanized PM-1 antibody is preferably derived from a human antibody REI, and the amino acid sequence is described in the FR1, FR2, FR3 and FR4 on the line of REI in Table 2 of International Patent Application WO 92/19759. Also, the framework region (FR) of the H chain V region of the above humanized PM-1 antibody is preferably derived from a human antibody NEW, and the amino acid sequence is described in the FR1, FR2, FR3 and FR4 on the line of NEW in Table 3 of International Patent Application WO 92/19759.

Furthermore, among the above V chains composed of the FR of a human antibody and the CDR of the mouse PM-1 antibody, the FR region may be modified in various manners to improve antigen-binding activity and neutralization activity. For example, the L chain V region is described in the FR1, FR2, FR3 and FR4 on the line of RV_{Lb} and RV_{La} in Table 2 of International Patent Application WO 92/19759 (termed version a to version b),

and the H chain V region is described in the FR1, FR2, FR3 and FR4 on the line of RV_Ha to RV_Hf in Table 3 of International Patent Application WO 92/19759 (termed version a to version f).

5 The L chain of the humanized PM-1 antibody is composed of the L chain V region mentioned above and the constant region (C region) of a human antibody L chain, and the H chain of the humanized PM-1 antibody is composed of the H chain V region mentioned above and the constant region (C region) of a human antibody H chain.
10 As the C region constituting the L chain, human γ -IC region is preferred, and as the C region constituting the H chain, human κ C region is preferred.

15 Glutamine, an N-terminal amino acid of a monoclonal antibody, is known to be pyroglutamylated, and in the subtypes 1 and 2 of the humanized PM-1 antibody of the present invention the N-terminal glutamine of the heavy chain may be pyroglutamylated. Thus the subtypes 1 and 2 of the humanized PM-1 antibody of the present invention 20 may be antibody subtypes in which the N-terminal glutamine (Gln) of the heavy chain is pyroglutamic acid (pGlu).

25 As the L chain and the H chain of the thus constructed humanized PM-1 antibody, as described above, there are various versions present by the modification of the FR region, and as a preferred example, there can be mentioned a H chain having the amino acid sequence set forth in SEQ ID NO: 1 and a L chain having the amino acid sequence set forth in SEQ ID NO: 2.

30 Incidentally, Escherichia coli (E. coli) DH5 α pPM-k3 containing a plasmid pPM-k3 comprising DNA encoding the L chain V region of the monoclonal antibody PM-1 has been internationally deposited as NCIMB 40366 and E. coli DH5 α pPM-h1 containing a plasmid pPM-h1 comprising DNA encoding the H chain V region of the monoclonal antibody 35 PM-1 has been internationally deposited as NCIMB 40362,

under the provisions of the Budapest Treaty on February 12, 1991, with the National Collections of Industrial and Marine Bacteria Limited (Ferguson Building, Craibstone Estate, Bucksburn, Aberdeen AB 21 9YA, United Kingdom).
5 The hybridoma PM1 producing the monoclonal antibody PM-1 has been internationally deposited as FERM BP-2998 under the provisions of the Budapest Treaty on July 12, 1989 with the Patent Microorganism Depository of the National Institute of Industrial Science and Technology (Chuo 6,
10 1-1, Higashi 1-chome, Tsukuba city, Ibaraki pref., Japan).

DNA encoding the L chain or the H chain having the amino acid sequence as described above may be constructed according to a standard method. Specifically, a DNA sequence which was designed to ligate the CDR of a mouse antibody with the framework region (FR) of a human antibody is synthesized by the PCR method from several divided oligonucleotides having sections overlapping with one another at the ends thereof. The DNA thus obtained
15 is ligated to a DNA encoding the C region of a human antibody and then is integrated into an expression vector, which is introduced into a host for antibody production (see European Patent Application EP 239400 and International Patent Publication WO 92-19759).
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For the FR of a human antibody ligated through CDR, those in which the complementarity determining region that forms a favorable antigen binding site are selected. When desired, amino acids in the framework region of the antibody variable region may be substituted so that the complementarity determining region of a reshaped human antibody may form an appropriate antigen binding site
25 (Sato, K. et al., Cancer Res. (1993) 53, 851-856).

For humanized antibody, the C region of a human antibody is used. As the C region of a human antibody,
30 there can be mentioned Cy, and Cy1, Cy2, Cy3, and Cy4, for example, can be used.

Antibody genes constructed as described above may be

expressed and obtained in a known method. In the case of mammalian cells, expression may be accomplished using a vector containing a commonly used useful promoter, the antibody gene to be expressed, DNA in which the poly A signal has been operably linked at 3' downstream thereof or a vector containing said DNA. Examples of the promoter/enhancer include human cytomegalovirus immediate early promoter/enhancer.

Additionally, as the promoter/enhancer which can be used for expression of antibody for use in the present invention, there can be used viral promoters/enhancers such as retrovirus, polyoma virus, adenovirus, and simian virus 40 (SV40), and promoters/enhancers derived from mammalian cells such as human elongation factor 1 α (HEF1 α).

For example, expression may be readily accomplished by the method of Mulligan et al. (Mulligan, R. C. et al., Nature (1979) 277, 108-114) when SV40 promoter/enhancer is used, or by the method of Mizushima et al. (Mizushima, S. and Nagata, S., Nucleic Acids Res. (1990) 18, 5322) when HEF1 α promoter/enhancer is used.

In the case of *E. coli*, expression may be conducted by operably linking a commonly used useful promoter, a signal sequence for antibody secretion, and the antibody gene to be expressed, followed by expression thereof. As the promoter, for example, there can be mentioned lacZ promoter and araB promoter. The method of Ward et al. (Ward, E.S. et al., Nature (1989) 341, 544-546; Ward, E.S. et al., FASEB J. (1992) 6, 2422-2427) may be used when lacZ promoter is used, and the method of Better et al. (Better, M. et al., Science (1988) 240, 1041-1043) may be used when araB promoter is used.

As the signal sequence for antibody secretion, when produced in the periplasm of *E. coli*, the pelB signal sequence (Lei, S. P. et al., J. Bacteriol. (1987) 169, 4379-4383) can be used. After separating the antibody

produced in the periplasm, the structure of the antibody is appropriately refolded before use (see, for example, WO 96/30394).

As the origin of replication, there can be used
5 those derived from SV40, polyoma virus, adenovirus, bovine papilloma virus (BPV) and the like. Furthermore, for the amplification of the gene copy number in the host cell system, expression vectors can include, as
10 selectable markers, the aminoglycoside phosphotransferase (APH) gene, the thymidine kinase (TK) gene, *E. coli* xanthine guanine phosphoribosyl transferase (Ecogpt) gene, the dihydrofolate reductase (dhfr) gene and the like.

For the production of antibody for use in the
15 present invention, any production system can be used. The production system for antibody preparation comprises an in vitro or an in vivo production system. As the in vitro production system, there can be mentioned a production system which employs eukaryotic cells and a
20 production system which employs prokaryotic cells.

When the eukaryotic cells are used, there are production systems which employ animal cells, plant cells, or fungal cells. Known animal cells include (1) mammalian cells such as CHO cells, COS cells, myeloma cells, baby hamster kidney (BHK) cells, HeLa cells, and Vero cells, (2) amphibian cells such as *Xenopus* oocytes, or (3) insect cells such as sf9, sf21, and Tn5. Known plant cells include, for example, those derived from *Nicotiana tabacum*, which may be subjected to callus culture. Known fungal cells include yeasts such as the genus *Saccharomyces*, more specifically *Saccharomyces cereviceae*, or filamentous fungi such as the genus *Aspergillus*, more specifically *Aspergillus niger*.

When the prokaryotic cells are used, there are
35 production systems which employ bacterial cells. Known bacterial cells include *Escherichia coli* (*E. coli*), and *Bacillus subtilis*.

By introducing, via transformation, the gene of the desired antibody into these cells and culturing the transformed cells *in vitro*, the antibody can be obtained. Culturing is conducted in the known methods. For 5 example, as the culture liquid, DMEM, MEM, RPMI1640, and IMDM can be used, and serum supplements such as fetal calf serum (FCS) may be used in combination. In addition, antibodies may be produced *in vivo* by 10 implanting cells, into which the antibody gene has been introduced, into the abdominal cavity of an animal and the like.

As *in vivo* production systems, there can be mentioned those which employ animals and those which employ plants. When animals are used, there are the 15 production systems which employ mammals and insects.

As mammals, goats, pigs, sheep, mice, and cattle can be used (Vicki Glaser, SPECTRUM Biotechnology Applications, 1993). Also as insects, silkworms can be used. When plants are used, tobacco, for example, can be 20 used.

Antibody genes are introduced into these animals or plants, and the antibodies are produced in such animals or plants and recovered. For example, an antibody gene is inserted into the middle of the gene encoding protein 25 which is inherently produced in the milk such as goat β casein to prepare a fusion gene. The DNA fragment containing the fusion gene into which the antibody gene has been inserted is injected into a goat embryo, and the embryo is introduced into a female goat. The desired antibody is obtained from the milk produced by the 30 transgenic goat borne to the goat who received the embryo or offsprings thereof. In order to increase the amount of milk containing the desired antibody produced by the transgenic goat, hormones may be given to the transgenic goat as appropriate. (Ebert, K.M. et al., Bio/Technology 35 (1994) 12, 699-702).

When silkworms are used, baculovirus into which the

desired antibody gene has been inserted is infected to the silkworm, and the desired antibody can be obtained from the body fluid of the silkworm (Maeda, S. et al., Nature (1985) 315, 592-594). Moreover, when tobacco is used, the desired antibody gene is inserted into an expression vector for plants, for example pMON 530, and then the vector is introduced into a bacterium such as Agrobacterium tumefaciens. The bacterium is then infected to tobacco such as Nicotiana tabacum to obtain the desired antibody from the leaves of the tobacco (Julian, K.-C. Ma et al., Eur. J. Immunol. (1994) 24, 131-138).

When antibody is produced in the in vitro or the in vivo production systems, as described above, DNA encoding the heavy chain (H chain) or the light chain (L chain) of antibody may be separately integrated into an expression vector and the hosts are transformed simultaneously, or DNA encoding the H chain and the L chain may be integrated into a single expression vector, and the host is transformed therewith (see International Patent Publication WO 94-11523).

In order to produce the subtypes 1 and 2 of the humanized PM-1 antibody of the present invention, preferably cultured cells, most preferably CHO cells, of an animal may be used as the host, and cultured in a culture medium for animal cells. Also the medium preferably contains peptone, a hydrolyzate of protein, and thus there can be used peptone derived from beef, pork, soy beans, rice, fish meat etc. Generally, animal-derived peptone has a high expression activity, and the use of fish meat-derived peptone (for example, bonito) has an effect on the amount expressed. In this case, when a medium containing a mammalian peptone is used to produce the humanized PM-1 antibody, little production of the subtypes 1 and 2 is observed, and when a medium containing a fish meat-derived peptone or a vegetable peptone is used to produce the humanized PM-1 antibody,

the ratio of the subtypes 1 and 2 becomes higher. Thus, in order to produce the subtypes 1 or 2 of the humanized PM-1 antibody of the present invention, preferably a cultured animal cell of the present invention, most preferably CHO cells, is used as the host, and it is cultured in a medium containing a fish meat-derived peptone or a vegetable peptone.

Antibodies produced and expressed as described above can be separated from the inside or outside of the host cell and then may be purified to homogeneity. Separation and purification of the antibody for use in the present invention may be accomplished by affinity chromatography. As the column used for such affinity chromatography, there can be mentioned Protein A column and Protein G column. Examples of the carriers used in the Protein A column are Hyper D, POROS, Sepharose F. F. and the like. Alternatively, methods for separation and purification conventionally used for proteins can be used without any limitation.

It can also be attained by chromatographies other than the above-mentioned affinity chromatography, such as commonly used chromatographies, for example, a combination of general column chromatographies such as ion exchange chromatography, hydrophobic chromatography, hydroxyapatite chromatography, gel-filtration and the like.

Furthermore; by combining, as appropriate, filtration, ultrafiltration, salting-out, dialysis and the like, the antibody for use in the present invention can be separated and purified. These chromatographies can be applied into fast protein liquid chromatography (FPLC) or high performance liquid chromatography (HPLC). Alternatively, reverse-phase HPLC can be used.

The concentration of antibody obtained in the above can be determined by the measurement of absorbance or by ELISA and the like. Thus, when absorbance measurement is employed, a sample is appropriately diluted with PBS(-)

and then the absorbance is measured at 280 nm, followed by calculation with 1.35 OD as 1 mg/ml. When the ELISA method is used, measurement is conducted as follows.

Thus, 100 μ l of goat anti-human IgG (manufactured by TAG) 5 diluted to 1 μ g/ml in 0.1 M bicarbonate buffer, pH 9.6, is added to a 96-well plate (manufactured by Nunc), and is incubated overnight at 4 °C to immobilize the antibody. After blocking, 100 μ l each of appropriately diluted antibody of the present invention or a sample containing 10 the antibody, or 100 μ l of human IgG (manufactured by CAPPEL) as the standard is added, and incubated at room temperature for 1 hour.

After washing, 100 μ l of 5000-fold diluted alkaline phosphatase-labeled anti-human IgG antibody (manufactured 15 by BIO SOURCE) is added, and incubated at room temperature for 1 hour. After washing, the substrate solution is added and incubated, followed by the measurement of absorbance at 405 nm using the MICROPLATE READER Model 3550 (manufactured by Bio-Rad) to calculate 20 the concentration of the desired antibody.

Since the subtype of the humanized PM-1 antibody of the present invention has substantially the same antigen-binding activity as the native humanized PM-1 antibody, it can be used similarly to the native humanized PM-1 25 antibody for the treatment or prevention of various diseases in which IL-6 is involved. Examples of IL-6-related diseases include acute and chronic inflammatory diseases, autoimmune diseases such as nephritis, mesangial proliferative nephritis, Crohn's disease, ulcerative colitis, pancreatitis, infantile chronic 30 arthritis or systemic juvenile idiopathic arthritis, vasculitis, Kawasaki disease, rheumatoid arthritis, systemic lupus erythematosus, psoriasis, Sjogren's syndrome and adult Still's disease; neoplastic diseases such as multiple myeloma, Castleman's disease, malignant 35 lymphoma and renal cancer; infectious diseases such as

HIV infection and EBV infection; cachexia; plasmacytosis, hyperimmunoglobulin disease, anemia and the like, and preferably rheumatoid arthritis, plasmacytosis, hyperimmunoglobulin disease, anemia, nephritis, cachexia, 5 multiple myeloma, Castleman's disease, mesangial proliferative nephritis, systemic lupus erythematosus, Crohn's disease, pancreatitis, psoriasis, and infantile chronic arthritis or systemic juvenile idiopathic arthritis.

10 The pharmaceutical composition of the present invention may be administered, either orally or parenterally, systemically or locally. For example, intravenous injection such as drip infusion, intramuscular injection, intrapleural injection, 15 intraperitoneal injection, subcutaneous injection, suppositories, intestinal lavage, oral enteric coated tablets, and the like can be selected, and the method of administration may be chosen, as appropriate, depending on the age and the conditions of the patient. The 20 effective dosage is chosen from the range of 0.01 mg to 100 mg per kg of body weight per administration. Alternatively, the dosage in the range of 1 to 1000 mg, preferably 5 to 50 mg per patient may be chosen.

25 Preferred dosages and preferred methods of administration are such that, in the case of anti-IL-6 receptor antibody, the amounts wherein free antibody is present in the blood are effective dosages. In specific examples, 0.5 mg to 40 mg per kg of body weight, preferably 1 mg to 20 mg, per month (4 weeks) are 30 administered in one to several divided doses, for example in the administration schedule of twice per week, once per week, once every two weeks, once every four weeks and the like by intravenous injection such as drip infusion and subcutaneous injection. The administration schedule 35 can be adjusted by observing the disease conditions and blood levels of laboratory tests by, for example, extending the administration interval from twice per week

or once per week to once per two weeks, once per three weeks, once per four weeks, and the like.

The pharmaceutical composition of the present invention may contain pharmaceutically acceptable carriers or additives depending on the route of administration. Examples of such carriers or additives include water, a pharmaceutical acceptable organic solvent, collagen, polyvinyl alcohol, polyvinylpyrrolidone, a carboxyvinyl polymer, carboxymethylcellulose sodium, polyacrylic sodium, sodium alginate, water-soluble dextran, carboxymethyl starch sodium, pectin, methyl cellulose, ethyl cellulose, xanthan gum, gum Arabic, casein, gelatin, agar, diglycerin, propylene glycol, polyethylene glycol, Vaseline, paraffin, stearyl alcohol, stearic acid, human serum albumin (HSA), mannitol, sorbitol, lactose, a pharmaceutically acceptable surfactant and the like. Additives used are chosen from, but not limited to, the above or combinations thereof depending on the dosage form.

Examples

The present invention will now be explained in more detail with reference to the working examples and reference examples. It should be noted, however, that the present invention is not limited to them in any way.

Example 1. The expression of an antibody composition containing the native humanized PM-1 antibody/subtype 1/subtype 2

Construction of expressing cells

(1) Preparation of human IL-6 receptor antibody PM-1

Anti-IL-6R antibody MT18 prepared by the method of Hirata et al. (J. Immunol., (1989) 143:2900-2906) was bound to CNBr-activated Sepharose 4B (manufactured by Pharmacia Fine Chemicals, Piscataway, NJ) according to the attached regimen, and IL-6R (Yamasaki, K. et al., Science (1988) 241:825-828) was purified.

Thus, a human myeloma cell line U266 was solubilized

with 1 mM p-paraaminophenyl methane sulfonyl fluoride hydrochloride (manufactured by Wako Chemicals) (digitonin buffer) containing 1% digitonin (manufactured by Wako Chemicals), 10 mM triethanolamine (pH 7.8) and 0.15 M NaCl, and mixed with the MT18 antibody bound to Sepharose 4B beads. Then, the beads were washed six times with the digitonin buffer to prepare the partially purified IL-6R to be used for immunization.

BALB/c mice were immunized four times every ten days with the above partially purified IL-6R obtained from 3×10^9 U266 cells, and then a hybridoma was prepared using a standard method. The culture supernatant of the hybridoma from the growth-positive well was tested for its activity of binding to IL-6R according to the method described below. 5×10^7 U266 cells were labeled with ^{35}S -methionine (2.5 mCi) and were solubilized with the above digitonin buffer.

The solubilized U266 cells were mixed with a 0.04 ml volume of MT18 antibody bound to Sepharose 4B beads, and then were washed six times with the digitonin buffer. ^{35}S -methionine-labeled IL-6R was eluted with 0.25 ml of the digitonin buffer (pH 3.4) and was neutralized in 0.025 ml of 1M Tris (pH 7.4). 0.05 ml of the hybridoma culture supernatant was mixed with 0.01 ml of Protein G Sepharose (manufactured by Pharmacia).

After washing, Sepharose was incubated with 0.005 ml of ^{35}S -labeled IL-6R solution prepared as described above. The immunoprecipitate was analyzed by SDS-PAGE to investigate the hybridoma culture supernatant that reacts with IL-6R. As a result, a reaction-positive hybridoma clone PM-1 was established. The IL-6R antibody PM-1 produced from the hybridoma PM-1 has a subtype of IgG1 κ .

The inhibitory activity of the antibody produced by the hybridoma PM-1 on the binding of IL-6 to human IL-6R was studied using the human myeloma cell line U266. A human recombinant IL-6 was prepared from *E. coli* (Hirano

et al., Immunol. Lett., (1988) 17:41), and was labeled with ^{125}I using the Bolton-Hunter reagent (New England Nuclear, Boston, MA) (Taga, T. et al., J. Exp. Med. (1987) 166:967). 4×10^5 U266 cells were cultured together with the culture supernatant of 70% (v/v) hybridoma PM-1 and 14,000 cpm of ^{125}I -labeled IL-6 in the presence of a 100-fold excessive amount of nonlabelled IL-6 at room temperature for 1 hour. Seventy μl of the sample was layered on 300 μl FCS in a 400 μl microfuge polyethylene tube. After centrifugation, the radioactivity of the cell was determined. The result revealed that the antibody produced by the hybridoma PM-1 inhibits the binding of IL-6 to IL-6R.

10 (2) Creation of humanized antibody hPM-1

15 Using a human elongation factor I α promoter described in Example 10 of International Patent Publication WO 92/19759 and according to the method described in Reference Example 2 of Japanese Unexamined Patent Publication (Kokai) No. 8-99902, a single expression vector containing both the L chain and H chain genes was constructed, and was investigated using CHO cells that produce the humanized PM-1 antibody (anti-human IL-6 receptor antibody), said cells being prepared by inserting the expression vector into CHO cells. The 20 ability of the humanized antibody obtained to bind to human IL-6R was confirmed by ELISA. Furthermore, hPM-1 inhibited the binding of human IL-6 to human IL-6R in a similar manner to a mouse antibody or a chimeric antibody.

25 30 Cell culture and the expression of humanized PM-1 antibody

In order to obtain a large quantity of humanized PM-1 antibody, the expressing cells were cultured in a commercially available serum-free medium and a modified medium. The culture condition was an environment 35 suitable for the culturing of CHO cells. In order to

increase the amount expressed of the desired antibody, various additives may be added to the medium. Among them, various types of peptones are widely used.

5 Peptones derived from beef, pork, soy beans, rice, fish meat etc. are widely commercially available. The effect depends on the compatibility with the cell line.

Generally, the effect of expression is high for animal-derived peptones. In the course of investigating the effect of various peptones, the use of a peptone derived 10 from fish meat (bonito) was found to be effective for the amount expressed.

The purification of the antibody expressed was accomplished by combinations of commonly used column chromatographies, for example, affinity chromatography, 15 ion exchange chromatography, hydrophobic chromatography, hydroxyapatite chromatography, gel-filtration and the like. In a molecular species of the humanized PM-1 antibody that was expressed by culturing CHO cells using a peptone derived from fish meat, there was observed a 20 molecular species that was present in scarce amounts when beef-derived peptone was used. This molecular species was also seen when a vegetable-derived peptone was used.

Example 2. Analysis of the humanized PM-1 antibody, the subtype 1 and the subtype 2

25 Materials and methods

As the materials, the native humanized PM-1 antibody (sometimes referred to as Main), the subtypes 1 and 2 of said antibody, and, as the reference peptides, a peptide Ser-Leu-Ser-Leu-Ser-Pro (SLSLSP) that is present at the 30 C-terminal of the humanized PM-1 antibody and in which Gly at the C-terminal has been removed and a peptide SLSLSP-NH₂ in which the C-terminal Pro has been amidated were used. The peptide SLSLSP and the amidated peptide SLSLSP-NH₂ were chemically synthesized. The humanized PM-35 1 antibody Main and the subtypes 1 and 2 of said antibody were obtained by subjecting the humanized PM-1 antibody obtained in Example 1 to a column chromatography and

collecting and purifying it by the following method.

The column used was the Poly CAT A (100×4.6 mm) manufactured by Poly LC, and the guard column used was the Poly CAT A Javelin guard (10×4.0 mm) manufactured by Poly LC. The mobile phases used were the mobile phase A (25 mM 2-[N-morpholino]ethanesulfonic acid buffer, pH 6.1, containing 0.05% NaN₃) and the mobile phase B (25 mM 2-[N-morpholino]ethanesulfonic acid buffer, pH 6.1, containing 250 mM sodium acetate and 0.05% NaN₃). As the 5 gradient condition, the ratio of the mobile phase B was 0 min/35%, 5 min/35%, 59 min/60%, and 60 min/100%. The 10 flow rate was 1 ml/min and detected by UV/VIS absorbance at 280 nm.

The enzymatic digestion of the humanized PM-1 antibody
15 Main, the subtype 1 and the subtype 2

200 µg equivalents of the humanized PM-1 antibody Main, the subtype 1 and the subtype 2 were placed in a simple ultrafiltration cartridge (Minicent, manufactured by Toso), into which a denaturant solution (100 mM 2-amino-2-hydroxymethyl-1,3-propanediol-hydrochloric acid 20 buffer, pH 8.3, containing 7 M guanidine and 1 mM ethylenediaminetetraacetic acid) was added to a liquid volume of 500 µl. The cartridge was centrifuged at 5°C to a liquid volume of about 50 µl. The sample was collected 25 into a microtube, to which a denaturant solution (the same composition as above) was added to make a total volume of 300 µl.

To each solution, 50 µl of a DTT solution (a denaturant solution containing 162 mM dithiothreitol) was 30 added and the head space was replaced with N₂, and allowed to stand in an incubating block at 37°C for 1 hour. Furthermore, 45 µl of the IAA solution (0.2 N sodium hydroxide solution containing 417 mM iodoacetic acid) was 35 added and allowed to stand in the dark at 37°C for 30 minutes. The reaction mixture was recovered, and each

sample was dialyzed, using dialysis tubing, against 500 ml of the Tris-HCl buffer (100 mM 2-amino-2-hydroxymethyl-1,3-propanediol-hydrochloric acid buffer, pH 8.0, containing 2 M urea) at 5°C for 20 hours (dialysis membrane: M.W.=8000, manufactured by Spectrum). The dialyzed samples were recovered and to each of them, 20 μ l of the trypsin solution (trypsin is dissolved in the Tris-HCl buffer (the same composition as above) to make 250 ng/ μ l) was added and allowed to stand at 37°C for 16 hours.

Analysis of the trypsin digests and the reference peptides

Forty μ l of each sample treated as above was subjected to the liquid chromatography-mass spectrometry (LC-MS/MS). For the reference peptide solutions, i.e. the SLSLSP solution (SLSLSP is dissolved in water to make 4 μ M) and the SLSLSP-NH₂ solution (SLSLSP-NH₂ is dissolved in water to make 4 μ M), 50 μ l is subjected to the liquid chromatography-mass spectrometry.

The condition for the liquid chromatography-mass spectrometry was as follows. Thus, the column used was the YMC-Pack ODS (250×2.0 mm, 5 μ m, 300 Angstrom) manufactured by YMC. The mobile phase used was the mobile phase A (5% acetonitrile solution containing 0.1% trifluoroacetic acid) and the mobile phase B (95% acetonitrile solution containing 0.1% trifluoroacetic acid). As the gradient condition, the ratio of the mobile phase B was 0 min/0%, 10 min/0%, 120 min/35%, and 140 min/35%. The flow rate was 0.2 ml/min and detection was by UV/VIS absorbance at 215 nm.

Result of analysis of the trypsin digests and the reference peptides

(1) Measurement of the reference peptide fragments
(a) Measurement of the peptide fragment SLSLSP

Fig. 1 to Fig. 3 show the result of liquid chromatography (LC)-mass spectrometry (MS) of the peptide

fragment SLSLSP. The top of Fig. 1 shows a chromatogram detected with a UV at 215 nm, and the bottom shows a chromatogram of a base peak chromatogram. Fig. 2 shows a mass spectrum, and Fig. 3 shows a zoom scan spectrum.

5 The molecular weight (602.2) obtained was in close agreement with the theoretical value (602.3; monoisotopic molecular weight) (Fig. 2 and Fig. 3).

(b) Measurement of the peptide fragment SLSLSP-NH₂

10 Fig. 4 to Fig. 6 show the result of liquid chromatography (LC)-mass spectrometry (MS) of the peptide fragment SLSLSP. The top of Fig. 4 shows a chromatogram detected with a UV at 215 nm, and the bottom shows a chromatogram of a base peak chromatogram. Fig. 5 shows a mass spectrum, and Fig. 6 shows a zoom scan spectrum.

15 The molecular weight (601.2) obtained was in close agreement with the theoretical value (601.3; monoisotopic molecular weight) (Fig. 5 and Fig. 6).

(c) Measurement of the mixture of the peptide fragments SLSLSP and SLSLSP-NH₂

20 Fig. 7 to Fig. 9 show the result of liquid chromatography (LC)-mass spectrometry (MS) of the mixture of the peptide fragment SLSLSP and SLSLSP-NH₂. The top of Fig. 7 shows a chromatogram detected with a UV at 215 nm, and the bottom shows a chromatogram of a base peak chromatogram. Fig. 8 shows the mass spectrum of a peak at a retention time of 44 minutes in Fig. 7, and Fig. 9 shows the mass spectrum of a peak at a retention time of 25 51 minutes in Fig. 7. The both peptide fragments were completely separated under the condition of the above 30 liquid chromatography.

(2) Analysis of the structure of the H chain C-terminal of the humanized PM-1 antibody

(a) Analysis of the structure of the H chain C-terminal of the humanized PM-1 antibody (Main)

35 Fig. 10 A shows a peptide map of peptides obtained by the reduction/carboxymethylation of the humanized PM-1 antibody (Main) followed by trypsin digestion. In order

to investigate the structure of the C-terminal fragment of the H chain, the MS chromatogram of SLSLSPG (selective monitoring at m/z 660.3 ± 0.5) is shown in Fig. 10 B, that of SLSLSP-NH₂ (selective monitoring at m/z 602.3 ± 0.5) in Fig. 10 C, and that of SLSLSP (selective monitoring at m/z 603.3 ± 0.5) in Fig. 10 D. A peak corresponding to SLSLSPG was detected at 49.7 minutes, but no peptide fragments having the molecular weight of SLSLSP-NH₂ and SLSLSP were found.

Fig. 11 to Fig. 13 show the result of LC-MS/MS analysis of a peptide obtained by the reduction/carboxymethylation of the humanized PM-1 antibody (Main) followed by trypsin digestion. The top in Fig. 11 shows a chromatogram detected by a UV at 215 nm and the bottom shows a base peak chromatogram. Fig. 12 shows a mass spectrum of the peak at a retention time of 50 minutes in Fig. 11, and Fig. 13 shows a zoom scan spectrum of the same peak as in Fig. 11. From these results, the detected peak was shown to have the amino acid sequence SLSLSPG. Thus, it was demonstrated that both C-terminals of the H chain of the humanized PM-1 antibody (Main) have the -SLSLSPG sequence.

(b) Analysis of the structure of the H chain C-terminal of the humanized PM-1 antibody subtype 1

Fig. 14 A shows a peptide map of peptides obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 1 followed by trypsin digestion. In order to investigate the structure of the C-terminal fragment of the H chain, Fig. 14 B shows the MS chromatogram of molecular weight of SLSLSPG (selective monitoring at m/z 660.3 ± 0.5). Fig. 14 C shows that of SLSLSP-NH₂ (selective monitoring at m/z 602.3 ± 0.5), and Fig. 14 D shows that of SLSLSP (selective monitoring at m/z 603.3 ± 0.5). In addition to a peak corresponding to SLSLSPG at 47.7 minutes, a peak corresponding to SLSLSP-NH₂ at 46.2 minutes was noted (though a peak with a

molecular weight of 603.3 was noted at about 46 minutes in Fig. 14 D, it is not SLSLSP, based on the retention time).

5 Fig. 15 to Fig. 17 show the result (on the peak in Fig. 14 B) of LC-MS/MS analysis of a peptide obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 1 followed by trypsin digestion. In Fig. 15, the top is a chromatogram detected by a UV at 215 nm and the bottom is a base peak chromatogram. Fig. 10 16 shows a mass spectrum of the peak at a retention time of 48 minutes in Fig. 15, and Fig. 17 shows a zoom scan spectrum of the same peak as in Fig. 16.

15 Fig. 18 to Fig. 20 show the result (on the peak in Fig. 14 C) of LC-MS/MS analysis of a peptide obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 1 followed by trypsin digestion. In Fig. 18, the top is a chromatogram detected by a UV at 215 nm and the bottom is a base peak chromatogram. Fig. 19 shows a mass spectrum of the peak at a retention time 20 of 46 minutes in Fig. 18, and Fig. 20 shows a zoom scan spectrum of the same peak as in Fig. 19.

25 From these results, the detected peak was shown to have the amino acid sequences SLSLSPG and SLSLSP-NH₂. Thus, it was demonstrated that one of the H chain C- terminals of the humanized PM-1 antibody subtype 1 has the -SLSLSPG sequence, and the other has the -SLSLSPG-NH₂ sequence.

(c) Analysis of the structure of the H chain C-terminal of the humanized PM-1 antibody subtype 2

30 Fig. 21 A shows a peptide map of peptides obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 2 followed by trypsin digestion. In order to investigate the structure of the C-terminal fragment of the H chain, Fig. 21 B shows the MS chromatogram of molecular weight of SLSLSPG (selective monitoring at m/z 660.3 ± 0.5), Fig. 21 C shows that of SLSLSP-NH₂ (selective monitoring at m/z 602.3 ± 0.5), and

Fig. 21 D shows that of SLSLSP (selective monitoring at m/z 603.3 ± 0.5). Though a peak corresponding to SLSLSPG was slightly detected, a peak corresponding to SLSLSP-NH₂ was more strongly noted (though a peak with a molecular weight of 603.3 was noted at about 45 minutes in Fig. 21 D, it is not SLSLSP, based on the retention time).

Fig. 22 to Fig. 24 show the result of LC-MS/MS analysis of a peptide obtained by the reduction/carboxymethylation of the humanized PM-1 antibody subtype 2 followed by trypsin digestion. In Fig. 22, the top is a chromatogram detected by a UV at 215 nm and the bottom is a base peak chromatogram. Fig. 23 shows a mass spectrum of the peak at a retention time of 45 minutes in Fig. 22, and Fig. 24 shows a zoom scan spectrum of the same peak as in Fig. 23. From these results, the detected peak was shown to have the amino acid sequence SLSLSP-NH₂. Thus, it was demonstrated that both of the H chain C-terminals of the humanized PM-1 antibody subtype 2 have the -SLSLSPG-NH₂ sequence.

Example 3. Measurement of biological activity of the humanized PM-1 antibody subtype 1 and subtype 2

(1) Determination of IL-6 receptor-binding activity

(a) Method of determination

The method of determination is as described in the following steps.

1) One hundred μ l of anti-IL-6 receptor antibody diluted to 5 μ g/ml with a sodium carbonate buffer, pH 9.6, is added to each well of an immunoplate, and allowed to stand in a cold place overnight or longer.

2) Each well is washed three times with 300 μ l of a phosphate buffered saline (hereinafter referred to as RB) containing 0.05% polysorbate 20.

3) To each well, 200 μ l of a Tris-HCl buffer, pH 8.1 (hereinafter referred to as DB), containing 1% bovine serum albumin is added, and allowed to stand at room temperature for 2 hours or longer.

4) After the liquid in the well is discarded, 100 μ l of a soluble IL-6 receptor diluted to 0.1 μ g/ml with DB is added to each well, and allowed to stand at room temperature for 2 hours.

5) Each well is washed three times with 300 μ l of RB.

10 6) To each well, 100 μ l of a sample solution serially diluted with a DB containing a given amount of biotinylated MRA is added, and allowed to stand at room temperature for 1 hour.

7) Each well is washed three times with 300 μ l of RB.

15 8) To each well, 100 μ l of a alkaline phosphatase-labelled streptoavidin diluted to 0.5 μ g/ml with DB is added, and allowed to stand at room temperature for 1 hour.

9) Each well of the immunoplate is washed five times with 300 μ l of RB.

20 10) A chromogenic reagent (SIGMA FAST p-nitrophenyl phosphate) is dissolved with water, and 100 μ l of it is added to each well, and allowed to stand at room temperature for 30 minutes.

11) The difference in absorbance at 405 nm and that at 655 nm of the reaction in each well is determined.

25 12) From the absorbance obtained, the binding activity of each sample is calculated using a parallel line test (3+3).

(b) Result

The result is shown in Table 1.

Table 1
Antigen-binding activity of humanized PM-1 antibody subtypes

Subtype	Activity	Specific activity
Native (Main)	1.04×10^3	100%
Subtype 1	1.13×10^3	109%
Subtype 2	1.12×10^3	108%

5 The result in Table 1 reveals that the humanized PM-1 antibody (Main), Subtype 1, and Subtype 2 have substantially the same antigen-binding activity.

(2) Inhibition of KT-3 cell growth

(a) Method of determination

10 The method of determination is as described in the following steps.

15 1) To each well of a microplate, 50 μ l of an IL-6 solution diluted to 2 ng/ml with a RPMI medium is added, and then 50 μ l of a sample solution serially diluted with a RPMI medium is added. To a blank well, 50 μ l of the RPMI medium is added.

20 2) Furthermore, 100 μ l of a KT-3 cell suspension adjusted to 5×10^4 cells/ml with the RPMI medium is added to each well, and cultured in a CO₂ incubator for 3 days.

25 3) To each well, 50 μ l of a ³H-thymidine solution appropriately diluted with the RPMI medium is added, and cultured in the CO₂ incubator for 6 days.

30 4) The cells in the microplate are collected on a glass filter using a cell harvester.

25 5) After drying the glass filter in a microwave oven for 10 minutes, a solid scintillator is impregnated into the glass filter under heating with a hot plate etc.

30 6) Using a liquid scintillation counter, radioactivity (cpm) is measured.

30 7) From the radioactivity obtained, the biological activity of each sample is calculated by a parallel line test (4+4).

The result is shown in Table 2.

Table 2

Activity of inhibiting cell growth of humanized PM-1
antibody subtypes

Subtype	Activity	Specific activity
Native (Main)	1.00×10^3	100%
Subtype 1	1.02×10^3	102%
Subtype 2	1.01×10^3	101%

5

The result in Table 2 reveals that the humanized PM-1 antibody (Main), Subtype 1, and Subtype 2 have substantially the same activity of inhibiting cell growth.